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Note on the Form of the Planet Saturn. By the Rev. R. Main.

My object in offering a few remarks on this subject, is to obviate any erroneous impressions which might arise from the publication, through mistake, of a paragraph of a letter from Mr. Dawes to Mr. De La Rue, in which doubts are expressed as to the correctness of the resulting ellipticity of the planet deduced by me in a paper printed in the 18th volume of the *Memoirs* of this Society. I have the authority of Mr. Dawes for stating that this portion of his letter was not intended for publication, and that his remarks on my result would have been very much modified if it had been so.

Since, however, any opinion expressed by so accomplished an observer must necessarily carry great weight with it (and in this instance a weight which he would probably not desire), I have thought it right to bring before the notice of the Society a few circumstances which additional research has brought to light, and which have not only confirmed me in my idea of the general correctness of my result, but which make it evident to *me* that it can scarcely be wrong by any significant quantity.

During the time of the visibility of the ring of *Saturn*, the effect of its vicinity to the equatoreal diameter produces so much confusion of the images in the use of a double-image eye-piece micrometer, or of a heliometer, that I doubt whether any trustworthy results could be at all produced, or at all events any results comparable with those deduced from the measures of a planet, without any such obstruction. I have never used a wire-micrometer for measuring *Saturn*, and I therefore do not profess to judge of the accuracy which might be practicable with it under similar circumstances; but my own impression is that the ring would prevent very great delicacy or accuracy in the measures. I, however, lay it down as a first principle, that *all measures made with a double-image apparatus capable of producing a definitive result for the ellipticity of the planet must be made during the time of the invisibility of the ring.*

When my paper was printed, I was actually ignorant of the existence of any extensive series of measures made for determining the form of *Saturn*, and this will be evident to any one reading the remarks in my introduction; and it was some time afterwards before my attention was directed to an excellent series made by Bessel with the Königsberg heliometer in the years 1830–1833, and printed at pp. 169, 170 of the 12th volume of the *Astronomische Nachrichten.* These measures were made with the same object as my own, viz. for the determination of the general form of the planet, as well as of the correct value of the ellipticity. None of them, however, were made during the time of the *total* disappearance of the ring, which took place for the first time at the end of September 1832. The ring reappeared in December 1832, vanished a second time near the end of April 1833, and finally re-

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appeared in June of the same year. The only observations recorded by Bessel during this period are included between 1832, Feb. 9 and March 31, and 1833, Feb. 22 and March 29, and during this interval the ring was so small that Bessel desisted from measures of it "because," to use his own words, "the small breadth of it did not appear advantageous for the purpose;" it was, therefore, a very proper time for determining with the heliometer the ellipticity of the planet. On three nights, viz. on Feb. 20, and March 1 and 31 of 1832, he measured the planet in five directions, and convinced himself of its elliptical shape: but we are not concerned with these measures in our present inquiry.

The final results given by Bessel, as deduced from the whole series of measures, and reduced to the mean distance of *Saturn* from the earth (whose log he takes to be 0·9796480), are as follows:—

	″		
Diameter of ring..................	= 39·311	from 44	observations
Equatoreal Diameter of *Saturn*	= 17·053	70	—
Polar Diameter	= 15·381	68	—

Hence the ellipticity is $\frac{1}{10\cdot2}$; and this is given by Mr. Hind and others as his definitive result.

If, however, we take the measures made when the ring had nearly disappeared, we shall find a result agreeing almost exactly with my own, and therefore preventing even that trifling doubt which arises from the difference between the above result and my own, $\frac{1}{9\cdot2}$.

I will for the sake of clearness give these measures, which are, when reduced to the mean distance, as follows:—

		Equatoreal Diam.	Polar Diam.	Difference.	No. of Measures.
		″	″	″	
1832, Feb.	9	16·89	15·03	1·86	2
	11	16·97	14·87	2·10	2
	13	16·91	14·95	1·96	1
	14	16·94	15·20	1·74	2
	15	17·18	15·23	1·95	2
	17	17·25	15·28	1·97	2
	20	17·22	15·24	1·98	1
March	1	17·00	15·35	1·65	3
	11	17·12	15·45	1·67	3
	16	16·93	...	...	
	31	17·25	15·34	1·91	3
1833, Feb.	22	16·97	15·06	1·91	3
	23	17·07	15·23	1·84	3
		16·95	15·18	1·77	3
	27	17·14	15·07	2·07	3
March	29	17·26	15·36	1·90	3

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The separate ellipticities deduced are as follows :—

1832, Feb.	9	Ellipticity =	$\frac{1}{9{\cdot}08}$	= 0·11013
	11	—	$\frac{1}{8{\cdot}08}$	= 0·12376
	13	—	$\frac{1}{8{\cdot}63}$	= 0·11587
	14	—	$\frac{1}{9{\cdot}74}$	= 0·10267
	15	—	$\frac{1}{8{\cdot}81}$	= 0·11351
	17	—	$\frac{1}{8{\cdot}76}$	= 0·11416
	20	—	$\frac{1}{8{\cdot}70}$	= 0·11494
March	1	—	$\frac{1}{10{\cdot}30}$	= 0·09709
	11	—	$\frac{1}{10{\cdot}25}$	= 0·09756
	31	—	$\frac{1}{9{\cdot}03}$	= 0·11074
1833, Feb.	22	—	$\frac{1}{8{\cdot}88}$	= 0·11261
	23	—	$\frac{1}{9{\cdot}28}$	= 0·10776
		—	$\frac{1}{9{\cdot}58}$	= 0·10438
	27	—	$\frac{1}{8{\cdot}28}$	= 0·12077
March	29	—	$\frac{1}{9{\cdot}08}$	= 0·11013

Taking the simple mean of the above results, which will be quite accurate enough for our present purpose, we get, for the definitive ellipticity deduced by Bessel by observations made when the ring had nearly disappeared, 0·11041, or $\frac{1}{9{\cdot}06}$, a result agreeing as closely with the value deduced by me as could be expected.

In the eleventh volume of the *Nachrichten*, No. 264, pp. 421, 422, I find some measures made by Dr. Hussey with a double-image micrometer, for the determination of the ellipticity of *Saturn*, during the time of the disappearance of the ring, extending from 1833, April 30, to May 20, when, as he remarks, "the planet was in the most favourable position for accuracy of micrometrical measurement." His final result for the diameters of *Saturn* at the unit of distances is,

$$\text{Equatoreal Diameter} = 2'\ 56''{\cdot}35$$
$$\text{Polar Diameter} = 2\ \ 40{\cdot}21$$

$$\text{Hence the ellipticity} = \frac{16{\cdot}14}{176{\cdot}35} = \frac{1}{10{\cdot}9}$$

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Dr. Hussey's observations were published for the purpose of exhibiting the advantage of a double-image micrometer over a wire-micrometer for measuring the diameters of planets. He at the same time measured *Jupiter*, and obtained for the ellipticity $\frac{1}{24\cdot9}$. It would appear, therefore, from this latter instance, that the tendency was to make the ellipticity too small rather than too large, since Struve's value, deduced from observations made with a wire-micrometer, is $\frac{1}{13\cdot7}$, and the mean of all the Greenwich observations with the double-image micrometer is between $\frac{1}{17}$ and $\frac{1}{18}$.

I will now proceed to a little farther discussion of my own measures, to obviate Mr. Dawes' objection that it is probable that the contacts for polar diameters may have been made by me too close on account of the dullness of the planet in their neighbourhood. For this purpose I will compare with the equatoreal diameters the means of the diameters measured at inclinations of 45° and 135°, since it is scarcely possible that the same objection can apply to these positions. They are reduced to the mean distance as follows:—

	Equat. Diam.	Mean of transverse Diam.
	″	″
1848, Sept. 20	18·53	17·51
22	18·75	17·58
Oct. 5	18·84	17·41
9	18·41	17·44
25	18·62	17·56
Nov. 15	18·18	17·59
21	18·65	17·75
1849, Jan. 26	18·83	18·13

It will be sufficiently accurate for our purpose, to take the mean of all the equatoreal diameters, and to compare it with the mean of all the transverse diameters. We get, then, for the former, 18″·60; and for the latter, 17″·62;

or, $a = 18''\cdot60$

$r = 17\cdot62$ at inclination of 45°.

Now, generally $$r = a\left(1 - \frac{\epsilon^2}{2}\sin^2\theta\right)$$

where $$\epsilon = \text{excentricity} = \sqrt{1 - \frac{b^2}{a^2}}$$

Hence, $$17\cdot62 = 18\cdot60 - \frac{9\cdot30}{2} \times \epsilon^2$$

or, $$4\cdot65 \times \epsilon^2 = 0\cdot98$$

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whence $$\varepsilon^2 = 0{\cdot}211 = 1 - \frac{b^2}{a^2}$$

$$\therefore \quad \frac{b^2}{a^2} = 0{\cdot}789$$

and $$\frac{b}{a} = 0{\cdot}8882$$

Hence $$e = 1 - \frac{b}{a} = 0{\cdot}1118 = \frac{1}{8{\cdot}94}$$

The resulting ellipticity deduced from the transverse diameters, as compared with the equatoreal diameters, is, therefore, larger by a trifling quantity than that deduced from the polar diameters, but the agreement between this result, Bessel's result from measures of polar and equatoreal diameters when the ring had nearly vanished, and my own published result, is surprisingly close,—the published result being the *smallest* of the three.

From all these circumstances I cannot help considering the determination of the ellipticity of *Saturn*, from the mean of the above three results, to be as certain as that of any astronomical element whatever, heretofore given.

I would finally remark, that the figure of *Saturn* drawn with my ellipticity, corresponds well with the image of *Saturn* which I saw so frequently during the disappearance of the ring; but that if I trusted solely to my impressions from memory, I should feel inclined to dissent from the result as being too small rather than too large.

Extracts of a Letter from the Rev. Mr. Stoddart, an American Missionary, to Sir John Herschel, Bart., dated Oroomiah, Persia, N. Lat. 37° 28′ 18″, *Long. E. from Greenwich* 45° 5′, *Oct. 29th*, 1852.

" No one has ever travelled in this country without being surprised at the distinctness with which distant objects are seen. Mountains fifty, sixty, and even a hundred miles off, are projected with great sharpness of outline on the blue sky; and the snowy peak of Ararat, the venerable father of mountains, is just as bright and beautiful when two hundred miles distant, as when we stand near its base. This wonderful transparency of the atmosphere frequently deceives the inexperienced traveller; and the clump of trees, indicating a village, which seems to rise only two or three miles before him, he will be often as many hours in reaching.

" In this connexion you will be interested to know that the apparent convergence of the sun's rays, at a point diametrically opposite its disk, which, if I mistake not, Sir David Brewster speaks of as a very rare phenomenon, is here so common that not a week passes in summer, when the whole sky at sunset is not striped with ribbons, very much like the meridians on an artificial globe.